it would. My working life has been passed in a great industrial region where this faint-hearted belief in the utility of science has been the one real obstacle to the progress of good science of every kind. At Leeds I have occupied myself greatly with the promotion of applied science, as in duty bound. But it has also been in the sure and certain hope that applied science, worthy of the name and really worthy of acceptance by industry, was indissolubly linked in bonds of mutual benefit to the purest and highest science that was ever dreamed of even by my chemical brethren, whose unworldly "stinks" profane the cloisters of more sequestered seats of learning.

It has been a hard fight, and though it would be unjust to say there have been no gains, I long since came to the conclusion that nothing short of a national cataclysm was likely to bring about anything approaching the change of heart that was so desirable and so necessary.

The cataclysm of war has, in fact, done this great thing for science. There is indisputable evidence of it, and I believe that at last British industry is generally, not exceptionally, on its way to use science well. That being so, I ask: Is there any possible escape for British industry and the British public from promoting pure science, and promoting it handsomely? I do not see it. Of course, they will not begin by endowing professorships in radio-activity or relativity, nor yet, perhaps, in that very pure chemistry which is the dearest thing to me; but they will be obliged to do it, and to do it before long. In the first instance, they will ask for what they now know they want: first-rate men who can apply science to the practical problems of industry. Already to a large extent they know that such men must have in them the root of the matter in the form of real scientific knowledge and skill, and it will follow as the day the night (if you so regard it) that science, pure and simple, must also be the object of their self-interested or patriotic solicitude.

I, for one, shall be glad to have it on those terms. For what, let us frankly say, are the alternatives for pure science? One I have just tried to set forth; the other, it seems to me, is a direct appeal for pure science, either because it is pure or because it is useful. If you extol it because it is pure, it is a worthy effort that I should honour with all my heart on one condition, and that is that you should avoid the incalculable mischief of trying to make out that there is in essence any distinction between pure and applied science, or that you should give just cause for the belief that there exists a brotherhood in science who set themselves up as the elect and disdain the implications of science in the practical arts that serve and preserve mankind.

If you extol pure science simply because it is useful —which by hypothesis you do not want to do—you embark on the task, long since essayed and long sustained, of teaching people by exhortation what at last they are in the way of finding out surely for themselves. To do that runs counter to all the precepts I have drawn from my experience of teaching.

I know very well what it is to be a prophet of pure science, even if only a minor or a minimus one, crying in the wilderness, and believe I can enter somewhat into the feelings of the major and maximus ones who are anxious and impatient under the present aspect of affairs. But they may be asked earnestly to consider the other point of view also, and to bethink themselves whether, after all, a great deal of the Philistinism of our people is not due to the detachment of locality, of interest, and of intercourse that in the past has been justly chargeable to the world of learning.

The British Association for the Advancement of Science was founded for the purpose of bringing a knowledge of science, its glories and its uses, among the people. It has done a great work, a much greater work than is known to those who will not sacrifice a week of the Alps or the oceans to do their bit and to experience the stimulus and profit derivable from the meetings—chiefly, it must be admitted, outside the section-rooms. The British Association needs revitalising, and I believe it can be revitalised. If our men of science would rally to it, it might do much that seems either to be neglected or to be falling into the hands of new organisations, the number of which alone, to say nothing of their particular distinctions or their subscriptions, is becoming quite bewildering.

It is, of course, the British way to have a multiplicity of disconnected organisations doing, or trying to do, much the same thing. We have won the war (it is true some others "also ran"), and Britain is justified in her institutions. To that no one subscribes more heartily than I, but we made some mistakes; and though organisation in the German way may be the mental path to inhumanity if followed far, I think we might profit by using a little more co-operation as we go our several ways.

Chemistry, it has been said, is a French science. Be that as it may, the immortal Lavoisier, who did more than anyone to revolutionise chemistry, began to investigate combustion because he was interested in lighting the streets of Paris. So at least says M. Le Chatelier, who is, I think, a chemist *assez pur*. According to my reading of history, so much pure science has arisen, not from the heavens above, but from the earth earthy beneath, that I will never, if I can help it, be penned off by any principality or power from the fraternity of applied science. Besides that, I owe them personally more than can ever be acknowledged for heading me off certain great dangers that threaten the academic life, and for helping me in countless ways with the promotion of pure science. We may rejoice without reserve in their temporary monopoly of popular favour. ARTHUR SMITHELLS.

The Theory of Hormones Applied to Plants.

No one would have read Prof. Bayliss's review (NATURE of December 12, p. 285) of Dr. Jacques Loeb's experiments on the "chemical correlationship" in plant growth with greater interest than John Hunter, for he had carried out many experiments on growing beans to elucidate the phenomena which are now explained on the theory of hormones. Hunter was familiar with phenomena of a similar kind in animals, and his experiments on plants were made primarily to elucidate that mysterious mechanism which went in Hunter's time under the name of "sympathy." An account of Hunter's experiments, carried out between 1772 and 1790, will be found in "Essays and Observations by John Hunter," edited by Sir Richard Owen, and published in 1861 (vol. i., p. 367). These observations were saved from destruction by William Clift. ARTHUR KEITH.

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RESEARCH ASSOCIATIONS AND OTHERS.

RESEARCH is the cry in every direction, but the public still needs instruction as to what it means and the conditions requisite for progress. Discovery of new principles on which advance can be made in the fundamental knowledge of Nature will probably be accomplished in the future, as in the past, through the genius of the few gifted men, but the dissemination of the right kind of knowledge and the creation of a widely diffused sentiment of respect for science and for scientific work depend largely on the future education of the people generally. Since it will probably always be true that public opinion is dependent more or less on authority, the action of the Government in setting up the Department of Scientific and Industrial Research is a step of the utmost importance. The work done by this body so far, however, relates to direct applications of science to practical purposes as revealed by the report for 1917–18 noticed in NATURE for October 17 last.

The protection of the interests of pure science, regardless of immediate utilitarian application, is, however, a matter of serious importance, and a movement has been set on foot at Cambridge with this object in view. The "Scientific Research Association" has been formed, and has put forward a scheme for its organisation and functions which at first sight appears not only very comprehensive, but also somewhat complicated. It is believed that science requires larger endowments and more co-ordinated and informed allocation of those endowments than is provided by any existing machinery. It is intended, therefore, to institute a comprehensive system of intelligence as to the research that is actually being done in the various branches of science, and of new research as it is projected. By those who are familiar with the position of workers in science in the past, how largely the work done has been accomplished at the cost in time, labour, and money of private individuals or in the scanty leisure of professional men, it will be agreed that if the national life is to be increasingly vitalised and the scientific habit of mind cultivated, it is essential that an assured career should be open to the competent worker. It is, therefore, proposed to formulate an extensive scheme of endowment of research by the State which would afford inducements to the most promising students to continue their pursuit of scientific investigation. This means an addition not only to the grants now made to universities, but also to the various schemes now afloat for providing maintenance scholarships and fellowships on a more extended scale. It is not proposed to advocate the separation of teaching and research, which have been hitherto associated in so many institutions with advantage to both.

Finally, the association contemplates taking a leading part in impressing on the public the importance of scientific research in all its aspects, and the fundamental value of scientific method in every department of national life. A very strong list of supporters has already been got together, but an examination of the list reveals the fact that, so far, for reasons which are not obvious, the promoters have not succeeded in getting the co-operation of some of the most eminent men of science in their several departments. For example, the president and other officers of the Royal Society are conspicuous by their absence, and as the president is one of the most famous physicists in the world, and Master of Trinity besides, he could not have been overlooked in connection with any scheme originating in Cambridge.

The fact is probably that while the time is certainly ripe for movement in the direction indicated by the proposed association, the scheme as at present formulated requires time and further consideration to secure the complete approval and adherence of all the leading men of science of the country. Moreover, complete concurrence in any one scheme is scarcely to be expected as yet while sympathy is so much divided by the various proposals which are in the air. The endowment of research will have to be further considered by the Government, though it is possible that in view of the money placed at the disposal of the Committee of the Privy Council for Scientific and Industrial Research, and the assignment of 100,000*l*. for research in connection with dyes, some people may feel that it will be well to watch the effects of this, and of other sources of endowment like that of the Salters' Company mentioned in NATURE for October 24, before proceeding further. It is true that there is in this country no institution corresponding with the Kaiser Wilhelm Institut near Berlin, or with the Wolcott Gibbs Institute at Harvard, but the establishment of a new college does not apparently enter into the programme drawn up by the promoters of the association. The Royal Institution with its connected Davy-Faraday Laboratory is unique in both constitution and output of results. It must not be forgotten, moreover, that nearly all the British universities have adopted a scheme for the institution of degrees open to candidates from overseas to be awarded on the results of research work performed by the candidate, and probably this will lead to further demands for assistance to these universities.

In the meantime the idea of bringing together the whole body of British men of science has resulted in the formation of another association under the name of "The National Union of Scientific Workers," concerning which a letter appeared in NATURE of October 24. The draft rules declare that the object of the union shall be, in the first place, "to advance the interests of science, pure and applied, as an essential element in the national life." The second object is "to regulate the conditions of employment of persons with adequate scientific training and knowledge, and their relations to their employers and to other employees," and among other things to set up a register of trained scientific workers and to establish an employment bureau. The promotion of scientific research is also mentioned, but it appears that the union assumes more the character of a professional body acting somewhat in the trade-union spirit than an association of persons interested in the promotion of scientific education and research. It will be evident, therefore, that the National Union would be unlikely to obtain much financial support from the public for the promotion of research, whereas an organisation like the Scientific Research Association may do so.

There is evidently a certain amount of overlapping in these movements. There has been formed within the last few months in the North of England an Association of Chemists with a similar professed purpose, but this has been merged, at least so far as the principal leaders are concerned, in the Institute of Chemistry, the chartered body to which nearly all the well-qualified chemists in the country are gravitating. But another step is now being taken in the creation of a Federation of Chemists which will include not only the highly qualified, but also men of all grades, and this will probably assume the features of a club with libraries and meeting-rooms. Science is evidently not going to be overlooked, but it would be unfortunate if any serious dissipation of energy should ensue before such compromises can be effected which will provide for the needs of all branches of science, pure and applied, and especially those cases in which, as between the chemists, metallurgists, and engineers, mutual help and recognition are most desirable.

THE FUTURE DEVELOPMENT OF THE INTERNAL-COMBUSTION ENGINE.

A BRILLIANT piece of analytical work has lately been given by Mr. H. R. Ricardo to the North-east Coast engineers and shipbuilders.[1] Mr. Ricardo takes as the title of his paper "High-speed Internal-combustion Engines," and in it he compares the modern high-speed engine with the older slow-speed type, much to the disadvantage of the latter—not merely in relation to speed, but also in respect of the degree of skill shown in design. There is great force in the arguments used, and the truth which is evident in not a few of them may legitimately be regarded as one of the outcomes of the war. The war had the effect of drawing out and stimulating the hitherto hidden abilities of numbers of energetically minded and scientifically trained engineers—mainly quite young men—who in the highly inelastic system of pre-war days received but trifling encouragement for either their inventive or their organising powers. The State cared little for scientific or technical research, and the leaders of industry were in too many cases quite as conservative as the State. Then came the awakening. The perils and dangers of war required that, for the supreme cause of the safety of the State, this attitude should be completely reversed—and reversed it was. Wide scope was at once given to all with inventive and scientific ability. One result we see in the amazing strides made in aviation—mainly the work of youth. When, therefore, Mr. Ricardo compares the older types of internal-combustion engine with the aero-engine of to-day he is comparing not merely two engines, but also two systems, two worlds in fact—one where the State is little concerned what technical developments its nationals may or may not produce, and one in which the State, fighting for its life, calls anxiously for the help of all talent to be found anywhere within its borders. But for the war aviation could not have developed at a pace in the least approaching that actually attained—and steadily maintained. This development is, as regards both numbers and efficiency, the outstanding technical achievement of the past four years; naturally it has demanded intensely rapid, even drastic, changes in the power unit of such craft. The heavy loading put on such engines has caused their design to be far more difficult than that of other internal-combustion engines; they may be required to run at high power (and that involving unprecedentedly high brake mean pressures) for so long as twenty hours on end. Types which have been constructed to weigh but two or three pounds per horse-power and yet run for hours on full load will afford a magnificent start to the aerial services of peace, especially since the less strenuous specifications of future operations will allow the engine to operate normally at powers quite appreciably below the maximum. The modern aero-engine is close to the highest perfection possible for its power and cycle. Any material further advance must, it would seem, be by change of cycle, change of fuel, or perhaps a break away to some new kind of prime mover altogether.

Mr. Ricardo correctly points out that "the design of internal-combustion engines in this country has during the last twenty years proceeded along two widely different lines directed by separated schools. On one hand, we have the designers of what may be termed the slow-speed type of engine, who have consistently had to compete with, and have based their designs upon, steam-engine practice; and, on the other, we have the designers of small high-speed engines who have appeared with the advent of the motor-car. The latter have created a school of thought of their own, and have developed along lines which are distinctly enterprising." The difference between high- and low-speed engines is by no means confined to a matter of speed, since the former usually run on petrol and the latter on gas. This difference in fuel is very important, though perhaps not permanent—a small "suction producer" added to a "petrol engine" would enable the latter to be run on gas directly derived from coal fed into the producer. This may come, but it seems to be some way off at present.

The difference between the use of petrol and gas is not merely one of supply and carriage, but is also of a more essential nature. Petrol has certain very valuable advantages. For one thing, a gas mixture suffers a chemical contraction on combustion, whereas a petrol mixture shows an expansion; the evaporation of petrol in the carburettor lowers the temperature of the incoming charge, so that the weight-volumetric efficiency of the suction stroke is higher than with gas. The disadvantages of petrol are less pronounced, though they certainly exist; thus there is usually some proportion of petrol which is not properly vaporised, and escapes combustion; and a stricter limitation of richness of charge is necessary.

These essential differences tend to complicate any comparison of the usual high-speed with the

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[1] Transactions of North-East Coast Institution of Engineers and Shipbuilders, vol. xxxiv., October, 1918.